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HARDENING OF MOLD PARTS AT GLASS FACTORIES

L. P. Barilovich,[1] V. N.Tkachuk,[1] L. P. Vergeles,[1] V. O. Mikulenok,[1] V. A. Rybakov,[1] and V. F. Palamarchuk[1]

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A method for hardening mold parts using boronizing is discussed; the regularities of modifications of part dimensions in boronizing are described; the aspects of machine treatment of boronized parts and the specifics of using diamond and other pastes and powders are considered.

The parts of glass-shaping molds are currently made of gray and high-strength modified cast iron and steel. These parts operate under increased temperatures (up to 1000°C) and impact loads. The high precision of dimensions and high-quality surface finish of glass articles require high-quality treatment of glass-shaping mold parts, which increases the cost of their manufacture. At the same time, the service life of these parts is not sufficient, which has a negative effect on production costs.

Hardening of parts using traditional methods does not significantly extend their service life. The surfacing method using costly equipment and imported surfacing powders (for instance, powders of the Colmonoy type) implemented at some factories is economically not effective, due to the high cost of such powder (15.3 US dollars per kg) and the absence of surfacing technology.

Purchase of foreign parts hardened with wear-resistant doping materials is expensive and increases the cost of production.

The Ukrainian Transport University (UTU) has recently developed a technology for hardening and restoration of parts using the boronizing method, and the new highly efficient oxide-free borate heat-carriers are widely used at several glass factories for hardening and restoration of molding equipment (Ukraine patent 7233A) [1]. Having high wear resistance and heat resistance [2], the boronized parts demonstrated good service life. Thus, the service life of a non-hardened plunger made of gray cast iron is around 5 h, whereas the service life of a plunger hardened by boronizing is 150 h.

The service life of a similar plunger made abroad and hardened by Colmonoy-225 surfacing powder is twice as high as that of boronized plungers, and yet the former is 10 times more expensive.

Thus, boronizing is the best method for hardening mold parts. The investments in technology and the necessary equipment and materials are repaid within a year, and in the case of large-scale production of glass articles it happens much sooner.

The simplicity of the technology does not require substantial expenditure on the equipment, nor high-skill workers. The technology uses a borate heat carrier consisting of several components, an electric furnace, and containers for placement and boronizing of parts.

The modification of part dimensions in hardening was studied as well in the course of production. Before boronizing begins, these size modifications are taken into account, and the tolerances of blanks are accordingly adjusted. It should be noted that the experiments performed at the UTU on samples and parts made of gray modified and high-strength cast iron indicated that as the temperature grows from 850 to 1000°C, the sizes increase according to the law $y = 0.5x^2 + 51.1x - 4$ after 2 h of boronizing and $y = -7.25x^2 + 109.15x - 40.75$ after 3 h of boronizing. In the calculations, it is necessary to substitute for x the coefficients 1, 2, 3 and 4 corresponding to 850, 900, 950, and 1000°C, respectively.

Modification of part sizes depends on the internal processes in the formation of new phases, namely, of iron borides which have a larger specific volume than the steel base.

According to the x-ray structural analysis data, an increase in the rate and decrease in the duration of boronizing leads to the formation only of the low-boron phase Fe_2B, which imparts good physicochemical properties to the part surface.

The process of saturation with boron in cast irons is relatively easy, since graphite insignificantly slows down the boronizing process. At the same time, graphite undergoes structural changes: instead of its laminar form in gray cast iron, it acquires the flocculent form [3].

Under considerable modifications of the structural and phase composition of cast iron, intense incremental and significant modification of the part sizes take place.

[1] Ukranian Transport University, Kiev, Ukraine; Gostomelskii Glass Works, Biomedsteklo Joint-Stock Company, Zhitomir, Ukraine.

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Considering the above, the regularities of part size increment depending on the boronizing conditions were established [1].

Control measurements of a substantial number of plungers hardened by boronizing employed in making glass jars Sh-TO66 305 at the Gostomelskii Glass Works indicated that the size increment in plungers was on the average 0.12 mm, whereas their diameter before boronizing was 56.2 mm. The plungers were made of gray cast iron SCh24 (GOST 1412–85). The surface roughness after mechanical treatment Ra = 2.5 μm. The size of the piece before boronizing was adjusted allowing for its increase.

The substantial hardness of the boronized layer caused difficulties in mechanical treatment (finish) of the part surface. The Ukrainian Transport University in cooperation with the Gostomelskii and Zhitomir glass factories developed technologies for finishing the working surface using diamond pastes, diamond tapes, and abrasive cloth.

It was established that the layer removed in mechanical treatment of boronized parts should not exceed 20 – 30% of the boronized layer thickness. Therefore, finishing to achieve the required size ought to be performed only by laps such as diamond pastes, pastes developed by GOI, Elbor, as well as diamond tapes and abrasive cloth. It is also possible to use various grades of diamond pastes which can provide for the required surface smoothness [4].

According to DSTU 3292–95, a certain classification of diamond powders and pastes is accepted in Ukraine. Thus, diamond pastes AM 60/40, ASM 60/40 – AM 28/20, and ASM 28/20 provide for the roughness of a part surface within the limits of Ra = 0.195 – 0.12 μm, pastes AM 20/14 – AM 10/7 provide for Ra = 0.095 – 0.06 μm, and pastes AM 7/5 – AM 1/10 provide for Ra = 0.045 – 0.02 μm. The necessary finish of the working surface of the part can be attained sooner using diamond tapes than using diamond pastes.

Along with using a diamond instrument in processing boronized parts, it is possible to use abrasive pastes based on boron carbide, Elbor, and GOI pastes.

When using pastes based on Elbor L25, L20, L16, the resulting surface finish is Ra = 1.25 – 0.32 μm, and using pastes based on Elbor L10 – L5 and boron carbide based on abrasive powder with grains 12 – 3 μm, the result is Ra = 0.63 – 0.16 μm. The best surface finish (Ra = 0.4 – 0.2 μm) is ensured using pastes based on Elbor micropowders LM40-LM1 and boron carbide M14, M10, M5. The same surface roughness can be accomplished using GOI pastes. The studies indicate that achieving a roughness Ra = 0.08 – 0.10 μm using GOI pastes, boron carbide, and Elbor takes 20 times longer than when diamond tools are used.

A certain quantity of graphite was added to prevent sintering of the heat carrier. Glass factories usually introduce inert additives in the form of quartz sand, alumina, magnesium oxide, pulverized feldspar etc. to the borate mixture. However, these additives contaminate the heat carrier and degrade its working efficiency.

The spectral analysis of boron carbide B_4C, which is one of the main components of the borate heat carrier, revealed that the main reason for sintering these mixtures is the increased amount of calcium compounds in boron carbide.

The Ukranian Transport University in cooperation with the glass factories is currently carrying out research to improve the efficiency of the boronizing process. New highly effective borate heat carriers have been developed.

As a consequence of the implementation of strengthening of molding equipment using the boronizing method, the service life of the parts has increased nearly 30 times. As the result of these activities, the time involved in replacing tools was substantially shortened, the total number of manufactured tool parts was reduced due to their increased longevity, and the transport expenses decreased significantly.

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